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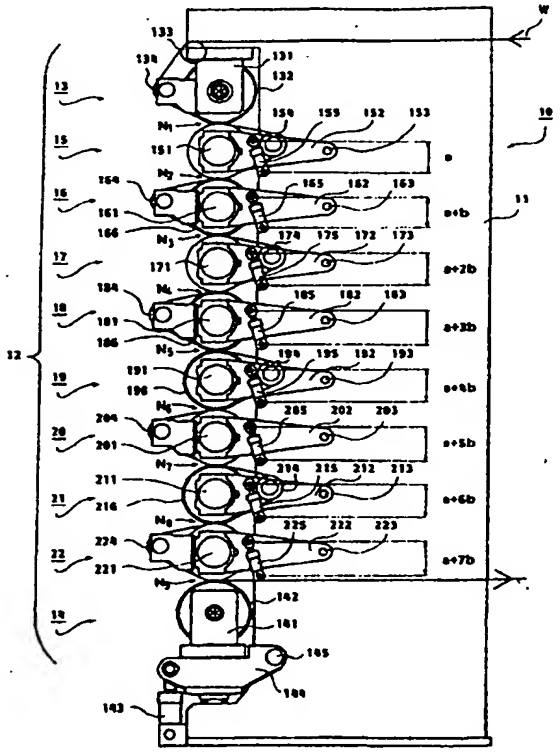
(54) Title: METHOD OF QUICK-OPENING A SET OF ROLLS IN A CALENDER, IN PARTICULAR IN A SUPERCALENDER, AND A HYDRAULIC SYSTEM FOR A SET OF ROLLS IN A CALENDER, IN PARTICULAR A SUPERCALENDER

(57) Abstract

The invention relates to a method of quick-opening a set of rolls in a calender, in particular a supercalender, in a calender (10) in which a paper or board web (W) to be calendered is passed through calendering nips (N_1-N_9) formed by a variable-crown top roll (13), a variable-crown bottom roll (14) and by two or more intermediate rolls (15-22) fitted between the top and bottom rolls (13, 14). The rolls (13-22) are arranged to form a substantially vertical stack of rolls (12), and the intermediate rolls (15-22) are supported by means of hydraulic relief cylinders (155-225) so as to relieve the nip load produced by the masses of bearing housings (151-221) of said intermediate rolls (15-22) and of auxiliary devices (154-224) associated therewith. During the quick-opening of the set of rolls, the bottom roll (14) of the set of rolls is lowered and the relief pressures in the hydraulic relief cylinders (155-225) are discharged so as to open the calendering nips (N_1-N_9). The hydraulic oil flowing out from the relief cylinders (155-225) is controlled by means of valves connected to the relief cylinders (155-225) of each intermediate roll (15-22) so that, during quick-opening of the set of rolls, the roll nips (N_1-N_9) may be opened in a controlled way in a desired order. The invention also relates to a hydraulic system for the set of rolls.



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Method of quick-opening a set of rolls in a calender, in particular in a supercalender, and a hydraulic system for a set of rolls in a calender, in particular a supercalender

The invention relates to a method of quick-opening a set of rolls in a calender, in particular a supercalender, in a calender in which a paper or board web to be calendered is passed through calendering nips formed by a variable-crown top roll, a variable-crown bottom roll and by two or more intermediate rolls fitted between the top and bottom rolls, which rolls are arranged to form a substantially vertical stack of rolls, and in which calender the intermediate rolls are supported by means of hydraulic relief cylinders so as to relieve the nip load produced by the masses of bearing housings of said intermediate rolls and of auxiliary devices associated therewith, and in which case, during the quick-opening of the set of rolls, the bottom roll of the set of rolls is lowered and the relief pressures in the hydraulic relief cylinders are discharged completely or partly so as to open the calendering nips.

The invention also relates to a hydraulic system for a set of rolls in a calender, in particular a supercalender, comprising a variable-crown top roll, a variable-crown bottom roll and two or more intermediate rolls fitted between the top roll and the bottom roll, which rolls are arranged to form a substantially vertical stack of rolls, the rolls placed one above the other in the set of rolls being in nip contact with one another and forming calendering nips therebetween, in which set of rolls the intermediate rolls are provided with hydraulic actuators, in particular with relief cylinders, so as to relieve the nip load produced by the masses of bearing housings of the intermediate rolls and of auxiliary devices associated therewith, such as, take-out rolls and equivalent, in which case, during operation, the hydraulic system is arranged to supply hydraulic oil to the relief cylinders under a desired pressure through valves.

The set of rolls in a supercalender conventionally comprises a plurality of rolls, which are arranged one above the other as a stack of rolls. The rolls placed one above the other are in nip contact with one another, and the paper or board web or equivalent to be calendered is arranged to run through the nips between the rolls. The rolls are journalled revolvingly on bearing housings, which in turn are normally attached to base parts fitted slidably on vertical guides provided in the frame of the calender. The base parts are suspended through stop parts on vertical lifting spindles provided in the frame of the calender, one of the functions of said lifting spindles thus being to act as guides to keep the rolls of the set of rolls in a correct position. Thus, the rolls of the set of rolls are not rigidly fixed at their bearing housings to the frame of the calender, but, instead, the rolls can move in a vertical direction.

The masses of the bearing housings of the rolls and of the auxiliary devices attached thereto, such as, take-out rolls, are quite large, which caused in conventional supercalenders the considerable drawback that said masses caused distortions in the distributions of the linear loads of the nips. For this reason, supercalenders started to employ relief devices, which are supported on the base parts of the rolls, on one hand, and on spindle nuts provided on the lifting spindles, on the other hand, so that the distortions caused by the weight of the bearing housings of the rolls and of the auxiliary devices attached thereto in the linear load profiles between the rolls were relieved by means of relief devices. One such arrangement has been previously disclosed, inter alia, in *US Patent 4,901,637*. The use of relief devices is previously known also from conventional machine calenders, in which attempts are made to eliminate, in particular, by means of hydraulic relief cylinders the above-mentioned effect of concentrated loads arising from the bearing housings of the rolls and from auxiliary devices.

In conventional sets of rolls of supercalenders provided with a lifting spindle, in connection with the quick-opening of the set of rolls, the rolls fall so as to rest on a nut of the lifting spindle situated below a bracket of the base part of the bearing housing. The quick-opening of the set of rolls has been carried out, as a rule, in such a way that the pressure has been discharged out from the lifting cylinder of the

bottom roll in the set of rolls or, in a similar way, in the case where as the bottom roll is used a roll which is adjustable in zones and in which the roll mantle is able to move over its entire length in a radial direction relative to the axle of the roll, the pressures have been discharged out from the loading members of the roll mantle so that the roll mantle has substantially moved relative to the axle of the roll, thereby allowing the intermediate rolls of the set of rolls to "fall" a certain distance downwards together with the roll mantle of the bottom roll. The movement of the lower intermediate rolls has been larger than the movement of the upper intermediate rolls in order to provide a gap of substantially equal size between the rolls. For this reason, the opening of the nips of the set of rolls has not been simultaneous, but, instead, the opening of the set of rolls has started from the uppermost nip, proceeding as a successive process towards the lowermost nip. This has usually taken place irrespective of whether or not any relief devices have been used in connection with the intermediate rolls. Additionally, the opening distances have been previously quite considerable because supercalenders previously employed fibre rolls, or so-called filled rolls, as soft rolls. The opening of the nips at different times has caused the considerable disadvantage that there have been substantial variations in the tension of the web and, consequently, there have always occurred web breaks in quick-opening. The broken end of paper has in turn run through the closed nips, which has resulted in the marking of soft rolls, which has further caused that the quality of paper has been completely spoilt, unless said marked roll has been replaced.

New supercalenders have begun to employ polymer rolls as soft rolls instead of fibre rolls, whereupon the total height variation of the set of rolls has remained considerably smaller than in conventional supercalenders that use filled rolls. One reason for this reduced total height variation has been the fact that variations in the diameters of soft rolls have been very small because the grinding allowances of said rolls are small. This reduced total height variation has in turn led to the fact that it has been possible to omit altogether the lifting spindles and the glide guides associated with conventional sets of rolls in a supercalender, and it has been possible to replace this construction with a so-called articulated set of rolls, where the intermediate rolls of the set of rolls are mounted on the frame of the calender by means of articulated

arms pivotally mounted on said frame. It has been possible to do so for the reason that, since the variations of the total height of the set of rolls are small, the vertical distance of movement required by an individual roll is small, and because of this, irrespective of the articulated attachment mode, the movements of the rolls relative to the nip level have also been very small when adjusting the height position of the roll.

One such very developed articulated set of rolls is disclosed, inter alia, in *FI Patent Application No. 935214*. However, the problem also with this kind of supercalender has been to make the nips of the set of rolls open simultaneously during quick-opening of the set of rolls. For this reason, the purpose of the present invention is to provide a method and a system by which the nips of the set of rolls can be opened in a controlled and a desired manner in the order desired during quick-opening, preferably such that the nips open simultaneously during quick-opening.

With a view to attaining the objectives of the invention, the method according to the invention is mainly characterized in that the hydraulic oil flowing out from relief cylinders is controlled by means of valves connected to the relief cylinders of each intermediate roll so that, during the quick-opening of the set of rolls, the roll nips may be opened in a controlled way in a desired order.

The hydraulic system according to the invention is mainly characterized in that the hydraulic system is arranged to supply relief cylinders with a hydraulic pressure which depends on the load acting on them and which pressure can, during the quick-opening of the set of rolls when the bottom roll in the stack of rolls has been lowered, be discharged from the relief cylinders of the intermediate rolls in a controlled way so that the calendering nips in the set of rolls may be opened in a desired order.

The invention provides significant advantages over prior art arrangements and of these advantages, among other things, the following may be stated. The quick-opening operation has been accomplished in the invention most advantageously

completely hydraulically so that the nips may be opened in a desired manner and quickly. In the most advantageous embodiment the invention is accomplished such that the nips open simultaneously. For instance, in a web break situation the simultaneous and quick opening of the nips is of crucial importance, because in supercalenders the quick-opening should, as a rule, take place even in a shorter time than half a second after a web break has been observed. This can be accomplished by the arrangement of the invention. The further advantages and characteristic features of the invention come out from the following detailed description of the invention.

In the following, the invention will be described by way of example with reference to the figures in the accompanying drawing.

Fig. 1 is a schematic side view of a calender to which the method and the system in accordance with the invention are applied.

Fig. 2 shows a hydraulic circuit diagram of the system in accordance with the invention in a situation where the calendering nips have been opened.

Fig. 2A shows by means of a circuit diagram corresponding to Fig. 2 a calender in a running position with the calendering nips closed.

Figs. 3A—3C, 4A—4C and 5A—5C show some alternative cylinder applications, which are suitable for use in the hydraulic system in accordance with the invention in relief cylinders of calender rolls.

Thus, Fig. 1 is a schematic side view of a supercalender in which the method and the system in accordance with the invention are applied. The supercalender in Fig. 1 is denoted generally with the reference numeral 10, and it comprises a calender frame 11, in which a stack of rolls 12 consisting of a number of rolls has been mounted in a vertical plane. The stack of rolls 12 comprises a top roll 13, a bottom roll 14, and a number of intermediate rolls 15—22 fitted one above the other

the top roll and the bottom roll, which rolls are all arranged in such a way that they are in nip contact with one another in a running situation. Fig. 1 shows the stack of rolls 12 of the calender expressly in the running position. A paper or board web W is passed in the example shown in Fig. 1 over a spreader roll 133 and a take-out roll 134 into an upper nip N_1 and further through other nips N_2—N_8 in the calender and finally out from a lower nip N_9. Between the nips N_1—N_9 the paper or board web W is taken apart from the face of the rolls by means of take-out rolls 154,164,174, 184,194,204,214,224. As shown in Fig. 1, the take-out rolls are situated alternatingly "outside" (take-out rolls 164,184,204,224) and "inside" (take-out rolls 154,174,194,214) the stack of rolls relative to the calender frame 11.

The top roll 13 in the calender is a variable-crown roll, whose bearing housing 131 in the embodiment of Fig. 1 is attached directly and rigidly to the calender frame 11. The axle of the variable-crown top roll 13 is mounted in said bearing housing 131, and the roll is provided, in a normal way, with internal loading means, by which the deflection of the roll mantle may be regulated in a desired way. The top roll 13 is a so-called soft roll and it is provided with a resilient polymer coating 132.

In a similar way, the bottom roll 14 in the calender is a variable-crown roll, whose roll mantle is mounted rotatably on the roll axle and which roll 14 is provided with internal loading means, by which the deflection of the roll mantle can be regulated in a desired way. The axle of the bottom roll 14 is mounted in bearing housings 141, which in the embodiment of Fig. 1 are mounted on loading arms 144, which are linked by means of articulated joints 145 to the calender frame 11. Between the calender frame 11 and the loading arms 144 there are mounted lower cylinders 143, by whose means the bottom roll 14 can be displaced in a vertical plane. Thus, the loading of the nips N_1—N_9 in the stack of rolls 12 can be provided by means of the lower cylinders 143 and, further, the stack of rolls 12 can be opened, if needed, by means of said lower cylinders 143. The internal loading means of the top roll 13 may also participate in the loading of the nips N_1—N_9 in the stack of rolls. Owing to the variable-crown bottom roll 14, the profiles of linear loads can be kept uniform in the nips N_1—N_9 in the stack of rolls 12. In the example of the figure the bottom

roll 14 is also provided with a polymer coating 142 corresponding to that of the top roll 13.

The intermediate rolls 15—22 in the stack of rolls 12 consist alternately of hard-faced and soft-faced rolls in such a way that, except the middle nip N_5 of the stack of rolls 12, in all the other nips one of the rolls is a hard-faced roll and the roll forming a nip therewith is a soft-faced roll. By soft-faced calender rolls are meant both modern rolls provided with a thin polymer coating and rolls provided with a coating made of a sheet material by pressing in an axial direction and conventionally used in the supercalender. The middle nip N_5 in the stack of rolls 12 is a so-called soft nip, in which both of the rolls forming the nip are soft-faced rolls. Thus, as the top roll 13 in the stack of rolls is a soft-faced roll, the uppermost intermediate roll 15 is a hard-faced roll. In a corresponding way, the second topmost intermediate roll 16 is a soft-faced roll provided with a resilient polymer coating 166 and, further, the following intermediate roll 17, or the third intermediate roll from the top, is a hard-face roll. As already stated above, the rolls 18 and 19 forming the middle nip N_5 are soft rolls provided with a resilient polymer coating 186,196, the next roll 20 downwards being again a hard-faced roll. The second lowest intermediate roll 21 is a roll provided with a polymer coating 216 and the lowermost intermediate roll 22 is a hard-faced roll.

In the calender shown in Fig. 1, bearing housings 151,161,171,181,191,201,211,221 of each intermediate roll 15—22 in the stack of rolls 12 are mounted on arms 152,162, 172,182,192,202,212,222, which are linked pivotally on the calender frame 11 by means of articulated joints 153,163,173,183,193,203,213 and 223 parallel to the axis of said rolls. The arms 152,162,172,182,192,202,212 and 222 are provided with relief devices 155, 165,175,185,195,205,215 and 225, which are pressure-medium operated piston-cylinder devices, most advantageously, hydraulic cylinders, which are attached at one end thereof to said arms of the intermediate rolls 15—22 and at the opposite end thereof to the calender frame 11. The so-called journal loads of the intermediate rolls, ie the loads caused by the bearing housings of the intermediate rolls 15—22 and by the auxiliary devices attached to the bearing housings,

can be relieved by means of said relief devices. The required relief forces are of different magnitude on the different intermediate rolls 15—22 since, as already stated previously, the take-out rolls, which are attached to the bearing housings of the intermediate rolls 15—22, are situated alternately on the inside and on the outside of the nip plane relative to the calender frame 11, and thus the loading caused by them on the relief devices is of different magnitude.

It has also already been stated above that in a situation where the stack of rolls is quickly opened the rolls 13—22 in the stack of rolls must be detached from one another in such a way that each of the nips N_1—N_9 opens, preferably an equal distance. In Fig. 1, which thus shows the calender 10 in a running position with the nips N_1—N_9 closed, attempts are made to illustrate this in such a way that the length of the relief device 155 of the topmost intermediate roll 15, ie the length of a projecting piston rod of a hydraulic cylinder, is denoted with the reference sign a. The size of the gap between the rolls required in quick-opening is in turn denoted with the reference sign b in Fig. 1. Consequently, the length of the projecting piston rod in the hydraulic relief device 165 of the second highest intermediate roll 16 must be a + b.

In a similar way, in the direction downwards in the stack of rolls 12, the length of the projecting piston rod in the relief device of each intermediate roll must be by said distance b greater than the length of the piston rod in the relief device situated above so that in the calender 10 shown in Fig. 1 comprising eight intermediate rolls the length of the projecting piston rod in the hydraulic relief device 225 of the lowermost intermediate roll 22 is a + 7b. In that case, when in a quick-opening situation the stack of rolls is opened by means of the lower cylinder 143 by lowering the bottom roll 14, there remains a gap of the size of the distance b in each nip N_1—N_9 when the piston rods of the hydraulic relief devices are at the bottom. Naturally, a gap larger than this may remain in the lowermost nip N_9 depending on the extent of the movement of the lower cylinder 143. Thus, during quick-opening the roll under each intermediate roll falls by the distance b more than the roll above. Because of the stresses directed by the quick-opening at the hydraulic relief devices

155,165,175,185,195,205,215 and 225, cushioned hydraulic cylinders must be used as relief devices. The operation of the system during quick-opening is described more closely by means of the hydraulic circuit diagram shown in Fig. 2.

Fig. 2 thus shows a hydraulic circuit diagram which accomplishes the method and the system in accordance with the invention. As already previously clearly stated, the invention primarily relates to the quick-opening of a set of rolls in a calender, and the invention is accomplished in such a way that the internal flow resistance of the hydraulic system is utilized during the quick-opening. The system thus enables the separation of the rolls of the system of rolls from one another as quickly as possible after a quick-opening signal has been received. In Fig. 2, the hydraulic relief devices of the intermediate rolls, ie the relief cylinders, are denoted with the reference signs 155,165,175,185,195,205,215 and 225 corresponding to Fig. 1. The diagram drawing shown in Fig. 2 also depicts the lowermost intermediate roll 22 of the set of rolls, which roll is the drive roll of the calender, and the articulated arm 222 of said drive roll, by which it is attached with an articulated joint to the calender frame not shown in Fig. 2.

The relief cylinders 155—225 of each intermediate roll in the set of rolls have a valve of their own 156,166,176,186,196,206,216 and 226, through which a required relief pressure is supplied to the relief cylinders in a running situation, and through which valves 156—226 the pressure is discharged from the relief cylinders 155—225 in a situation where the calender is quick-opened. In accordance with Fig. 2, said valves 156—226 are preferably hydraulically controlled valves, for instance, directional control valves shown in the figure. The hydraulic circuit diagram of the system is divided, in a way, into four sections such that, firstly, the hydraulic system comprises a first pressure circuit 31', through which the same filling pressure is supplied to the side of the piston rod of all the relief cylinders 155—225. Thus, the relief cylinders are double-acting hydraulic cylinders, as shown by Fig. 2. The filling pressure is supplied to the side of the piston rod of the relief cylinders mainly for the reason that, in a quick-opening situation, the relief cylinders can be made

shorter quickly by the action of said filling pressure when their relief pressure has been discharged.

The first pressure circuit comprises an adjustable valve 31, for instance, a controlled pressure valve, through which pressure is supplied from a pressure supply line of the system to a pressure line 31b leading to the side of the piston rod of the relief cylinders 155—225. The first pressure circuit is additionally provided with a pressure gauge 31a or equivalent, by which the pressure of the first pressure circuit is monitored. Further, the first pressure circuit is fitted with a reservoir 30 for a pressure medium, or hydraulic oil, said reservoir being preferably placed at the upper part of the hydraulic system. The purpose of the reservoir 30 is to ensure a sufficiently rapid supply of oil to the side of the rod of the relief cylinders 155—225 in a quick-opening situation.

The hydraulic system comprises, in addition, separate pressure circuits 32',33',34' for the relief cylinders 165,185,205 of the intermediate rolls provided with an external take-out roll, for the relief cylinders 144,175,195,215 of the intermediate rolls provided with an internal take-out roll and separately for the relief cylinder 225 of the lowermost intermediate roll, ie the drive roll 22. These separate pressure circuits are necessary specifically for the reason that, on one hand, the different locations of the take-out rolls produce different loads on the relief cylinders, so naturally it must be possible to load them with a different pressure. On the other hand, the loads directed to the drive roll 22 differ from the load of all the other intermediate rolls, so said drive roll 22 must have a separate pressure circuit of its own. Thus, each of these separate pressure circuits 32',33',34' comprises an adjustable valve 32,33,34, which is preferably of a type corresponding to the valve 31 of the first pressure circuit 31', through which valve hydraulic oil from the pressure supply line of the hydraulic system is passed to respective pressure lines 32b,33b,34b. Further, these pressure circuits are provided with pressure gauges 32a,33a,34a or equivalent means. Hydraulic oil is passed from said pressure circuits to the relief cylinders 155—225 through the valves 156—226. As already previously stated, said valves 156—226 are hydraulically controlled valves and these valves

receive their necessary control pressure through the valve 35, which thus controls jointly all the valves 156—226 of the relief cylinders 155—225.

Fig. 2 specifically shows a quick-opening situation where the pressures have been discharged under the piston of the relief cylinders 155—225. In such a quick-opening situation, pressure has been removed from the loading cylinder 143 of the bottom roll 14 of the calender, in which case the bottom roll 14 has been lowered. Before the quick-opening situation, the hydraulic system has been in an operation state corresponding to Fig. 2A, where the valve 35 controlling the valves 156—226 of the relief cylinders 155—225 has supplied the hydraulically controlled valves 156—226 with a control pressure, which has maintained said valves against the spring-load of the valves in the position shown in Fig. 2A in such a way that the hydraulic oil has been allowed to get under the piston of the relief cylinders 155—225 through the pressure circuits 32',33',34' in order to provide a required relief force. In the quick-opening situation shown in Fig. 2, said valve 35 has moved to the position shown by said Fig. 2, in which case the control pressure of the valves 156—226 of the relief cylinders 155—225 has discharged and the spring-load of the valves has displaced the valves from the position shown in Fig. 2A to the position shown in Fig. 2, in which the pressure connection from the pressure circuits 32',33', 34' to the relief cylinders 155—225 has been cut off and, correspondingly, the connection from below the piston of the relief cylinders 155—225 to a reservoir 40 has been opened.

As clearly depicted in Fig. 2, in a quick-opening situation the valves 156—226 of the relief cylinders 155—225 are connected in series in such a way that the hydraulic oil flowing out from each relief cylinder 155—225 is guided through the valve 166—226 of the next relief cylinder below, in which case, in the fashion shown by Fig. 2, the hydraulic oil flowing out from all the relief cylinders 155—225 finally passes through the valve 226 of the relief cylinder 225 of the lowermost intermediate roll, ie the drive roll 22. This means that the hydraulic oil flowing out from the relief cylinder 155 of the uppermost intermediate roll 15 meets the highest flow resistance, because the oil flowing out from said relief cylinder has to pass through

the valves of the relief cylinders of all the intermediate rolls 15—22. The flow resistance decreases correspondingly in the direction downwards in the set of rolls.

As shown in Fig. 1, in a quick-opening situation the lowest intermediate roll, or the drive roll 22, must perform the largest vertical movement, while the required movement of the topmost intermediate roll 15 is the smallest. In accordance with the illustration of Fig. 1, the necessary displacement of the intermediate rolls increases in the direction from above downwards. This in turn means that, if it is desired to cause all the nips N_1—N_9 of the set of rolls to open simultaneously, the opening or falling velocity of the lowest intermediate roll 22 must be the highest and this falling velocity must decrease in the direction upwards in the set of rolls. In the invention this condition is satisfied because, as already stated above, the rate of the flow out from the relief cylinder 225 of the lowermost intermediate roll 22 is the highest, since the flow resistance is correspondingly the lowest. The flow resistance increases in the direction upwards, in which case the rate of flow of the oil out from the relief cylinders naturally decreases. This, of course, affects linearly the movement velocity of the relief cylinders. Thus, in the arrangement in accordance with the invention, gaps begin to be formed between the rolls 13—22 immediately after the valves 156—226 of the relief cylinders 155—225 have moved from the position shown in Fig. 2A to the position shown in Fig. 2.

As the hydraulic drawing sign representing the valve 35 in Figs. 2 and 2A seeks to illustrate, an electromagnetically controlled valve is preferably used as the valve 35. Besides providing a very quick action, said valve 35 can be easily connected electrically in the electric system of the calender 10, for instance, to such an automatic system that identifies web breaks, if such an automatic system is available in the calender.

The above description of the invention has described, with reference to the figures, an arrangement in which the flow resistances in the path of the hydraulic oil flowing out from the relief cylinders 155—225 are arranged in such a way that the calender nips N_1—N_9 open simultaneously in the entire roll stack 12. It is, however, com-

pletely possible to arrange and to regulate the flow resistances in the path of the hydraulic oil flowing out from the relief cylinders 155—225 in such a way that the nips N_1—N_9 can be caused to open in a controlled way in the order considered to be necessary. However, as stated, the hydraulic circuit described provides the simultaneous opening of the nips.

It is also clear from the above description that in a quick-opening situation the intermediate rolls 15—22 of the set of rolls have to be supported by the relief cylinders 155—225 in their entirety. Thus, in particular in a quick-opening situation, the relief cylinders are subjected to quite considerable loads, so cylinders provided with cushioning shall be used as the relief cylinders. In spite of this, and especially for the reason that the invention provides a very fast opening of the nips N_1—N_9, it may be necessary to also use a separate stop which is based, for instance, on friction and which receives totally or at least partly the loads arising from quick-opening.

As already explained above, it is advantageous to cause the roll nips to open simultaneously in the quick-opening of the set of rolls in a supercalender. In a certain way this might be considered problematic because, as it is stated clearly, for instance, in connection with Fig. 1, the opening distances of the roll nips N_1—N_9 of the set of rolls are unequal in length and because of this the opening speeds of the nips must also be different. It must be possible to take care of this variation of opening distances and opening speeds by means of the hydraulic system and, in particular, by means of the relief cylinders connected to the hydraulic system. Figs. 3A—3C, 4A—4C and 5A—5C illustrate some alternative solutions as to how the relief cylinders can be accomplished in a manner fulfilling the requirements set on them.

Figs. 3A—3C show a hydraulic cylinder, which is generally denoted with the reference numeral 50. When conventional hydraulic cylinders comprise, as a rule, two operating positions, for instance, a pressurized working position and an un-pressurized free position, the hydraulic cylinder 50 comprises, in addition to these

two positions, also a third operating position, which is between these two positions and to which position the hydraulic cylinder can be stopped without complicated control circuits. The hydraulic cylinder 50 comprises a cylinder part 51, inside which a piston 52 is fitted in a normal way so as to be axially movable. The bottom of the cylinder part 51 is replaced by a partition wall 55, through which a special measuring cylinder 53 is connected to the cylinder part 51. A second piston 54, or the piston of the measuring cylinder, is fitted inside the measuring cylinder 53 so as to be also axially movable. Thus, in the arrangement shown in Figs. 3A—3C the measuring cylinder 53 functions directly as an extension of the cylinder part 51. The partition wall 55 is provided with a large-diameter opening extending therethrough, the extension 56 of the piston of the measuring cylinder being capable of being pushed from the measuring cylinder 53 into the cylinder part 51. Thus, end faces 58,59 of the piston 52 and the piston 54 of the measuring cylinder can be brought against each other so as to be in contact with each other, as illustrated in Fig. 3A. A spring means 57, for instance, a set consisting of cup springs, a spiral spring or equivalent is fitted to the bottom of the measuring cylinder 53, said spring serving as cushioning for the piston 54 of the measuring cylinder. The measuring cylinder 53 is provided with a pressure connection 60 and with a drain connection 61 and the cylinder part 51 of the hydraulic cylinder is provided with a pressure connection 62 and with a drain connection 63, respectively. The control pressure 64 of the hydraulic cylinder 50 is passed to these pressure connections 60,62 in such a way that the control pressure is passed to the pressure connection 62 of the cylinder part 51 through valves 66,67, which in the illustration of Figs. 3A—3C are one-way restrictor valves allowing free flow in one direction and restricting it in the other direction (said directions are opposite in the valves 66,67). Similarly, the drain connections 61,63 are connected to a drain duct 65.

In Fig. 3A the hydraulic cylinder 50 is shown in an unpressurized state, in which case the piston 52 is pressed to the bottom of the cylinder part 51 by the action of the external load acting on the piston 52. When applied, for instance, to the calender shown in Fig. 1, the situation of Fig. 3A may correspond to a service position, in which case all pressures have been removed from the relief cylinders. As shown by

Fig. 3A, the piston 52 is pressed against the piston 54 of the measuring cylinder further in such a way that the piston 54 of the measuring cylinder is pressed against the spring means 57 situated at the bottom of the measuring cylinder 53.

Fig. 3B shows the hydraulic cylinder 50 in its first working position, which, when applied to the calender of Fig. 1, corresponds to the running position of the calender, in which the calendering nips are closed. In that case, oil has been supplied from the pressure duct 64 through the pressure connection 60 to the measuring cylinder 53 and through the pressure connection 62 to the cylinder part 51. The piston 54 of the measuring cylinder has then moved together with the piston 52 in the illustration of Fig. 3B to the right, or outwards from the cylinder, until the piston 54 of the measuring cylinder has stopped at the partition wall 55. Before resting on the partition wall 55, the piston extension 56 of the measuring cylinder has rested against the piston 52 in such a way that the ends 58,59 of the pistons are against each other to balance pressure forces. This is due to the fact that the same pressure prevails on both sides of the piston 54 of the measuring cylinder and that the area on the side of the partition wall 55 of the piston 54 of the measuring cylinder is smaller. When the pressure has been further increased, hydraulic oil has flown between the pistons 54 and 52 through the pressure connection 62, until the piston 52 has reached its extreme position, that is, until an external obstruction has stopped the movement of the piston 52. In the calender this means precisely the situation shown in Fig. 1, where the nips are closed. Fig. 3C shows a situation where pressure has been removed from the pressure duct 64. When applied to the relief cylinders of the calender, this corresponds to a quick-opening situation. In that case, when pressure has been removed from the duct 64, the piston 54 of the measuring cylinder is immediately pressed to the bottom of the measuring cylinder 53 against the spring means 57 by the action of an external load. The spring means 57 thus provides cushioning in the hydraulic cylinder. The piston 52 of the cylinder part 51 has then naturally moved at the same speed an equivalent distance to the left in Fig. 3C and, if the valve 66 is controlled so as to be closed, the distance between the pistons 54 and 52 remains constant and the piston 52 stops at the position shown in Fig. 3C. Pressure is allowed to discharge freely through the valve 67, since said

valve 67 restricts the flow and the pressure only in one direction. If again the valve 66 is not controlled so as to be closed, oil discharges from the cylinder part 51 at a desired speed through said valve 66, until the situation corresponding to Fig. 3A is reached. If the valve 66 is replaced, for instance, by a pressure-controlled lock valve, it is possible to move in both directions between the positions shown in Figs. 3B and 3C depending on the position of said valve 66 and on the pressure prevailing in the pressure duct 64. The extent of the movement of the piston rod of the piston 52 in the cylinder part 51 between the positions shown in Figs. 3B and 3C is determined by the play of the piston 54 of the measuring cylinder 53 and by the diameters of the cylinders.

In the construction of Figs. 3A—3C the measuring cylinder 53 is placed directly in connection with the cylinder part 51, but it can also be placed apart from the cylinder part, since with regard to operation a mechanical connection between the piston 54 of the measuring cylinder and the piston 52 of the cylinder part is not necessary. Such arrangements have been illustrated by way of example in Figs. 4A—4C and 5A—5C. The numbering of said figures corresponds to the numbering of Figs. 3A—3C in so far as the constructions correspond to each other. In Figs. 4A—4C, however, the hydraulic cylinder has been denoted generally with the reference numeral 50a and in Figs. 5A—5C with the reference numeral 50b.

The hydraulic cylinder 50a shown in Figs. 4A—4C largely corresponds in structure to the structure shown in Figs. 3A—3C such that also in the arrangement of Figs. 4A—4C a measuring cylinder 53 is placed directly as an extension of a cylinder part 51. In the structure shown in Figs. 4A—4C, a partition wall 55, however, cuts off the mechanical connection between a piston 52 of the cylinder part and a cylinder 54 of the measuring cylinder, while a connecting duct 55a is formed into the partition wall 55 so as to extend therethrough so that the cylinder part 51 and the measuring cylinder 53 are in hydraulic connection with each other. A pressure connection 62 opens into said connecting duct 55a. The operation of the hydraulic cylinder 50a is equivalent to that already explained in connection with Figs. 3A—3C.

In the position depicted in Fig. 4A, the hydraulic cylinder 50a is unpressurized. An external force acting on the arm of the piston 52 in the cylinder part 51 presses the piston 52 against the partition wall 55 and, in a similar way, a spring means 57 fitted to the bottom of the measuring cylinder 53 presses the piston 54 of the measuring cylinder against the partition wall 55. When hydraulic oil is supplied from a pressure duct 64 into the hydraulic cylinder through pressure connections 60 and 62, the piston 54 of the measuring cylinder remains in the position shown in Fig. 4B against the partition wall 55 and the piston 52 of the cylinder part 51 moves to the position of Fig. 4B. The piston 54 of the measuring cylinder remains in place for the reason that the same pressure prevails on both sides of said piston and that the effective area below the piston 54 of the measuring cylinder is considerably larger than on the side of the partition wall 55. Thus, the hydraulic cylinder 50a is shown in Fig. 4B in a position corresponding to that of Fig. 3B and in this regard reference is made to the description in connection with Fig. 3B.

In Fig. 4C the hydraulic cylinder 50a is shown in a situation corresponding to that of Fig. 3C. In that case the control pressure prevailing in the pressure duct 64 has been removed, and the pressure below the piston 52 of the cylinder part 51 and prevailing in the connecting duct 55a has pressed the piston 54 of the measuring cylinder to the bottom of the measuring cylinder. In other respects, especially regarding the operation of valves 66,67, reference is made to the description already completely given in connection with Fig. 3C. If the pressure is discharged totally out from the cylinder part 51, the piston 52 is first pressed to the bottom of the cylinder part 51 against the partition wall 55 and, after that, the spring means 57 pushes the piston 54 of the measuring cylinder from the other side against the partition wall 55. This, then, is the situation shown in Fig. 4A.

Figs. 5A—5C depict a further embodiment of a hydraulic cylinder 50b, which is in operation identical with the arrangement shown in Figs. 4A—4C. Also in structure, the arrangement of Figs. 5A—5C differs from that of Figs. 4A—4C only in the respect that the measuring cylinder 53 in this embodiment is not directly an axial extension of the cylinder part 51, but, instead, the measuring cylinder 53 is turned

so as to be at an angle relative to the cylinder part 51, said angle being 90° in Figs. 5A—5C. Regarding the operation of this application, reference is made completely to that which has already been explained in connection with Figs. 3A—3C and 4A—4C.

The movements of the hydraulic cylinder illustrated in Figs. 3A—3C, 4A—4C and 5A—5C can also be easily provided with different movement velocities. A desired return movement from a working position may be determined for the cylinder. In operation, this kind of cylinder is suitable especially for a place where the length of the cylinder in working position varies from time to time and it is, however, desired that the piston of the cylinder shall move specifically a desired distance in a direction away from the working position. This kind of operation is needed, in addition to the relief cylinders of the calender in accordance with the invention, in a working cylinder of a brake, where the length of the working position of the cylinder changes with the wearing down of the brake material and, nevertheless, it is possible to provide, after the braking has stopped, a clearance of constant magnitude for the brake in order to prevent dragging. This property has been achieved by passing the oil discharging from the cylinder during a return movement to a special measuring cylinder. The length of the return movement of the cylinder can be affected in a desired manner by means of the diameter and the length of the measuring cylinder.

Above, the invention has been described by way of example with reference to the figures in the accompanying drawing. The invention is, however, not confined to the exemplifying embodiments shown in the figures alone, but different embodiments of the invention may vary within the scope of the inventive idea defined in the accompanying claims.

Claims

1. A method of quick-opening a set of rolls in a calender, in particular a supercalender, in a calender (10) in which a paper or board web (W) to be calendered is passed through calendering nips (N_1—N_9) formed by a variable-crown top roll (13), a variable-crown bottom roll (14) and by two or more intermediate rolls (15—22) fitted between the top and bottom rolls (13,14), which rolls (13—22) are arranged to form a substantially vertical stack of rolls (12), and in which calender the intermediate rolls (15—22) are supported by means of hydraulic relief cylinders (155—225) so as to relieve the nip load produced by the masses of bearing housings (151—221) of said intermediate rolls (15—22) and of auxiliary devices (154—224) associated therewith, and in which case, during the quick-opening of the set of rolls, the bottom roll (14) of the set of rolls is lowered and the relief pressures in the hydraulic relief cylinders (155—225) are discharged completely or partly so as to open the calendering nips (N_1—N_9), **characterized** in that the hydraulic oil flowing out from the relief cylinders (155—225) is controlled by means of valves (156—226) connected to the relief cylinders (155—225) of each intermediate roll (15-22) so that, during quick-opening of the set of rolls, the roll nips (N_1—N_9) may be opened in a controlled way in a desired order.

2. A method as claimed in claim 1, **characterized** in that, in connection with quick-opening of the set of rolls, the valves (156—226) controlling the relief cylinders (155—225) of all the intermediate rolls (15—22) are connected to open substantially simultaneously.

3. A method as claimed in claim 1 or 2, **characterized** in that, during quick-opening, the valves (156—226) controlling the relief cylinders (155—225) are controlled in such a way that, in the flow path of the oil flowing out from the relief cylinders (155—225), the oil flowing out from the relief cylinder (155) of the uppermost intermediate roll (15) has the highest flow resistance, the flow resistance being lower in the oil flowing out from the relief cylinder of each intermediate roll below in such a way that the oil flowing out from the relief cylinder (225) of the

lowermost intermediate roll (22) has the lowest flow resistance, in which case all the calendering nips (N_1—N_9) open substantially simultaneously.

4. A method as claimed in any one of the preceding claims, **characterized** in that, in a situation where the set of rolls is opened quickly, the hydraulic oil flowing out from the relief cylinders (155—225) is passed through the valve controlling the next relief cylinder below, in which case the pressure of the relief cylinder (155) of the uppermost intermediate roll (15) is discharged through all the valves (156—226) controlling the relief cylinders, the pressure of the relief cylinder (225) of the lowermost intermediate roll (22) being discharged only through its own valve (226), respectively.

5. A method as claimed in any one of the preceding claims, **characterized** in that the valves (156—225) of the relief cylinders (155—225) of the intermediate rolls (15—22) are controlled hydraulically by a valve (35), which provides a control impulse simultaneously to all the valves (156—226) of the relief cylinders (155—225).

6. A method as claimed in any one of the preceding claims, **characterized** in that, during quick-opening of the set of rolls, the movement of the piston (52) of the relief cylinders (50,50a,50b) is stopped or the movement is at least highly decelarated before the piston (52) is moved to the bottom after a desired quick-opening distance has been reached.

7. A method as claimed in claim 6, **characterized** in that the movement of the piston (52) of the relief cylinders (50,50a,50b) is controlled by means of a measuring cylinder (53) connected to a cylinder part (51).

8. A hydraulic system for a set of rolls in a calender, in particular a supercalender, comprising a variable-crown top roll (13), a variable-crown bottom roll (14) and two or more intermediate rolls (15—22) fitted between the top roll (13) and the bottom roll (14), which rolls are arranged to form a substantially vertical stack of rolls (12),

the rolls (13—22) placed one above the other in the set of rolls being in nip contact with one another and forming calendering nips (N_1—N_9) therebetween, in which set of rolls the intermediate rolls (15—22) are provided with hydraulic actuators, in particular with relief cylinders (155—225), so as to relieve the nip load produced by the masses of bearing housings (151—221) of the intermediate rolls (15—22) and of auxiliary devices associated therewith, such as, take-out rolls and equivalent (154—224), in which case, during operation, the hydraulic system is arranged to supply hydraulic oil to the relief cylinders (155—225) under a desired pressure through valves (156—226), **characterized** in that the hydraulic system is arranged to supply the relief cylinders (155—225) with a hydraulic pressure which depends on the load acting on them and which pressure can, during the quick-opening of the set of rolls when the bottom roll (14) in the stack of rolls (12) has been lowered, be discharged from the relief cylinders (155—225) of the intermediate rolls (15—22) in a controlled way so that the calendering nips (N_1—N_9) in the set of rolls may be opened in a desired order.

9. A hydraulic system as claimed in claim 8, **characterized** in that the hydraulic system is divided into several separate pressure circuits in such a way that at least the hydraulic relief cylinders (155,175,195,215) of the intermediate rolls (15,17, 19,21) provided with a take-out roll (154,174,194,214) situated on the inside relative to a calender frame (11) have a pressure circuit (33') of their own, the hydraulic relief cylinders (165,185,205) of the intermediate rolls (16,18,20) provided with a take-out roll (164,184,204) situated on the outside relative to the calender frame (11) have a pressure circuit (32') of their own, the relief cylinder (225) of the drive roll (22) of the calender has a pressure circuit (34') of its own and, in addition, the hydraulic system comprises a separate pressure circuit (31'), which is arranged to supply each relief cylinder (155—225) with a counterpressure of equal magnitude acting in a direction opposite to the relief pressure.

10. A hydraulic system as claimed in claim 8 or 9, **characterized** in that, in a situation where the set of rolls is opened quickly, the valves (156—226) controlling

the relief cylinders (155—225) are arranged to discharge the relief pressure acting in the relief cylinders (155—225) substantially simultaneously.

11. A hydraulic system as claimed in any one of claim 8—10, **characterized** in that the flow resistances in the flow paths of the hydraulic oil flowing out from the relief cylinders (155—225) are arranged in such a way that the flow resistance in the flow path of the uppermost relief cylinder (155) is the highest and the flow resistance in the flow path of the lowermost relief cylinder (225) is the lowest, the flow resistance being stepwise reduced in the direction from the relief cylinder (155) of the uppermost intermediate roll (15) to the relief cylinder (225) of the lowermost intermediate roll (22).

12. A hydraulic system as claimed in any one of claims 8—11, **characterized** in that, in a situation where the set of rolls is opened quickly, the valves (156—226) controlling the relief cylinders (155—225) are connected in series in such a way that the oil flowing out from the relief cylinders (155—225) passes through the valve of the next relief cylinder below, in which case the oil flowing out from the uppermost relief cylinder (155) passes through all the valves (156—226) controlling the relief cylinders and the pressure of the lowermost relief cylinder (225) discharges only through its own valve (226), respectively.

13. A hydraulic system as claimed in any one of claims 8—12, **characterized** in that the valves (156—226) of the relief cylinders (155—225) are hydraulically controlled valves and that the hydraulic system is provided with a valve (35), which is arranged to supply a control pressure to all the valves (156—226) of the relief cylinders.

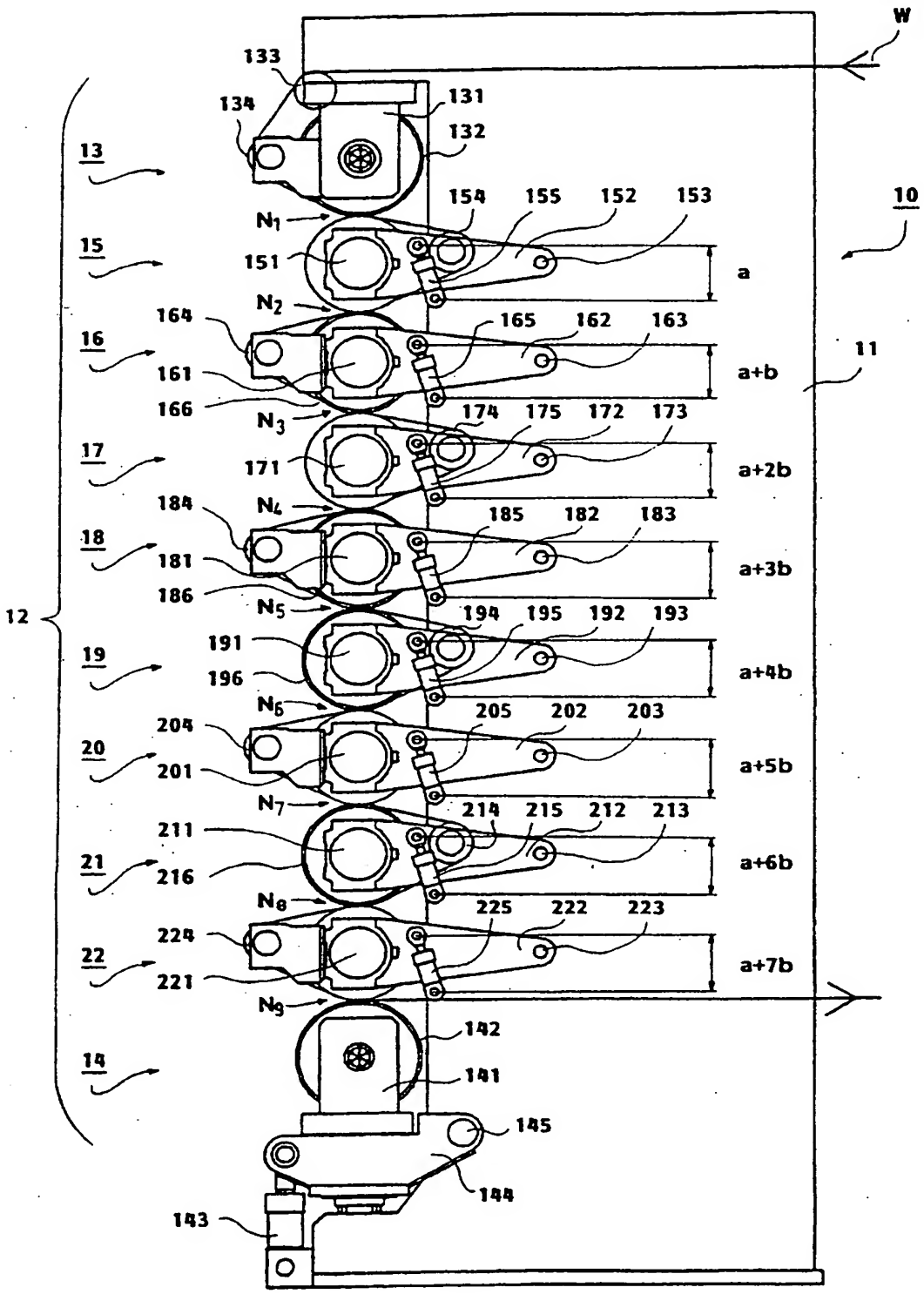
14. A hydraulic system as claimed in any one of claims 8—13, **characterized** in that the hydraulic system is provided an oil reservoir (30), which is connected to the pressure circuit (31') supplying a counterpressure to the relief cylinders (155—225), in order to ensure a sufficiently quick supply of oil to the cylinders in a quick-opening situation.

15. A hydraulic system as claimed in any one of claims 8—14, **characterized** in that the relief cylinders (50,50a,50b) are three-position hydraulic cylinders, the movement of whose piston (52) can be stopped or at least highly decelerated during quick-opening of the set of rolls after a desired quick-opening distance has been reached before the piston (52) is moved to the bottom.

16. A hydraulic system as claimed in claim 15, **characterized** in that a measuring cylinder (53) controlling the movement of the piston (52) of the relief cylinder during quick-opening is connected to the relief cylinders (50,50a,50b).

17. A hydraulic system as claimed in claim 16, **characterized** in that the coupling between the measuring cylinder (53) and the relief cylinder (50) is such that the pistons (52,54) of the measuring and relief cylinders can be brought to a mechanical connection with each other.

18. A hydraulic system as claimed in claim 16, **characterized** in that the pistons (52,54) of the relief cylinder (50a,50b) and the measuring cylinder (53) are in direct hydraulic connection with each other.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161
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166
N3
174
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a+3b
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N6
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N7
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216
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FIG. 1

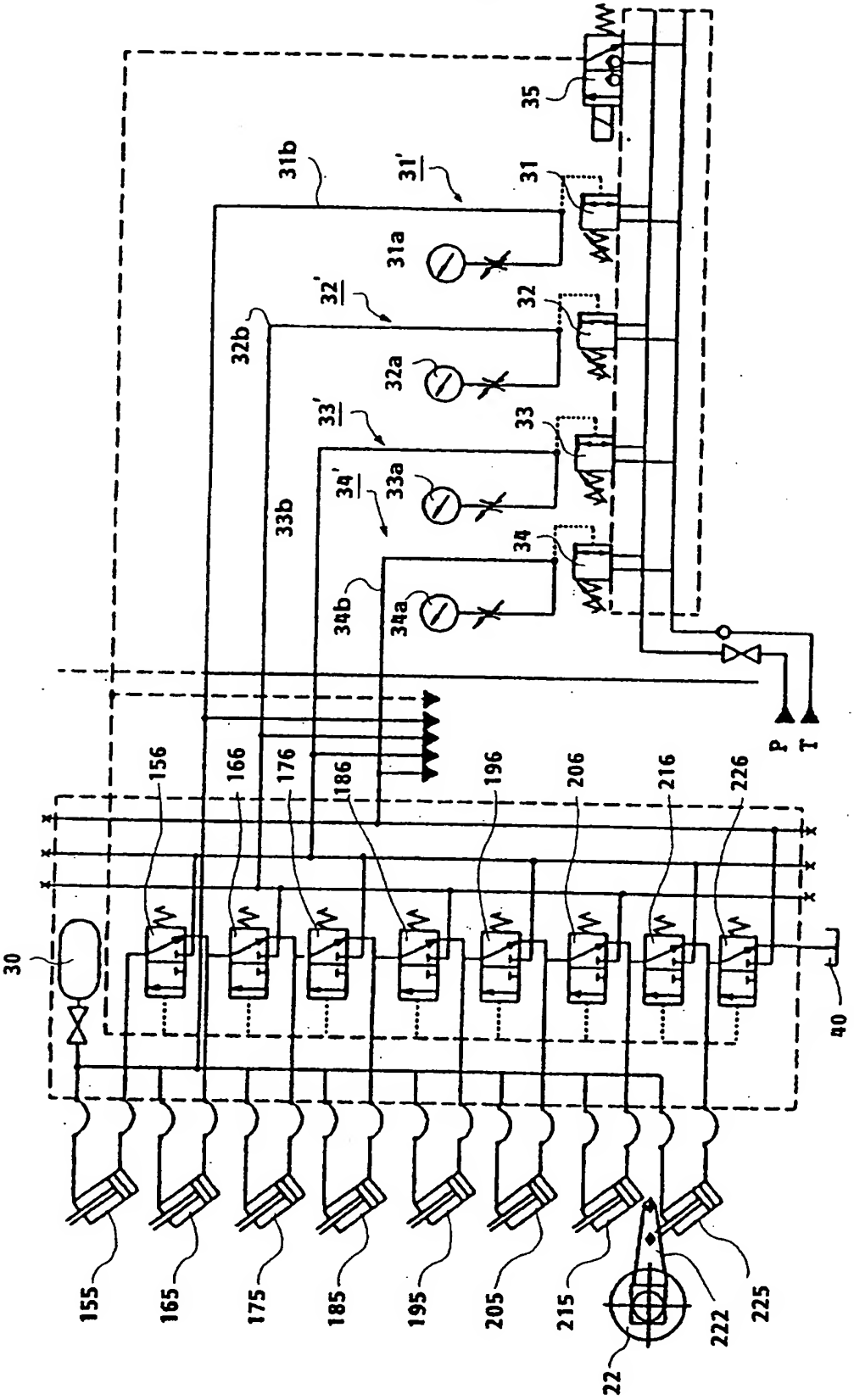
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FIG. 2

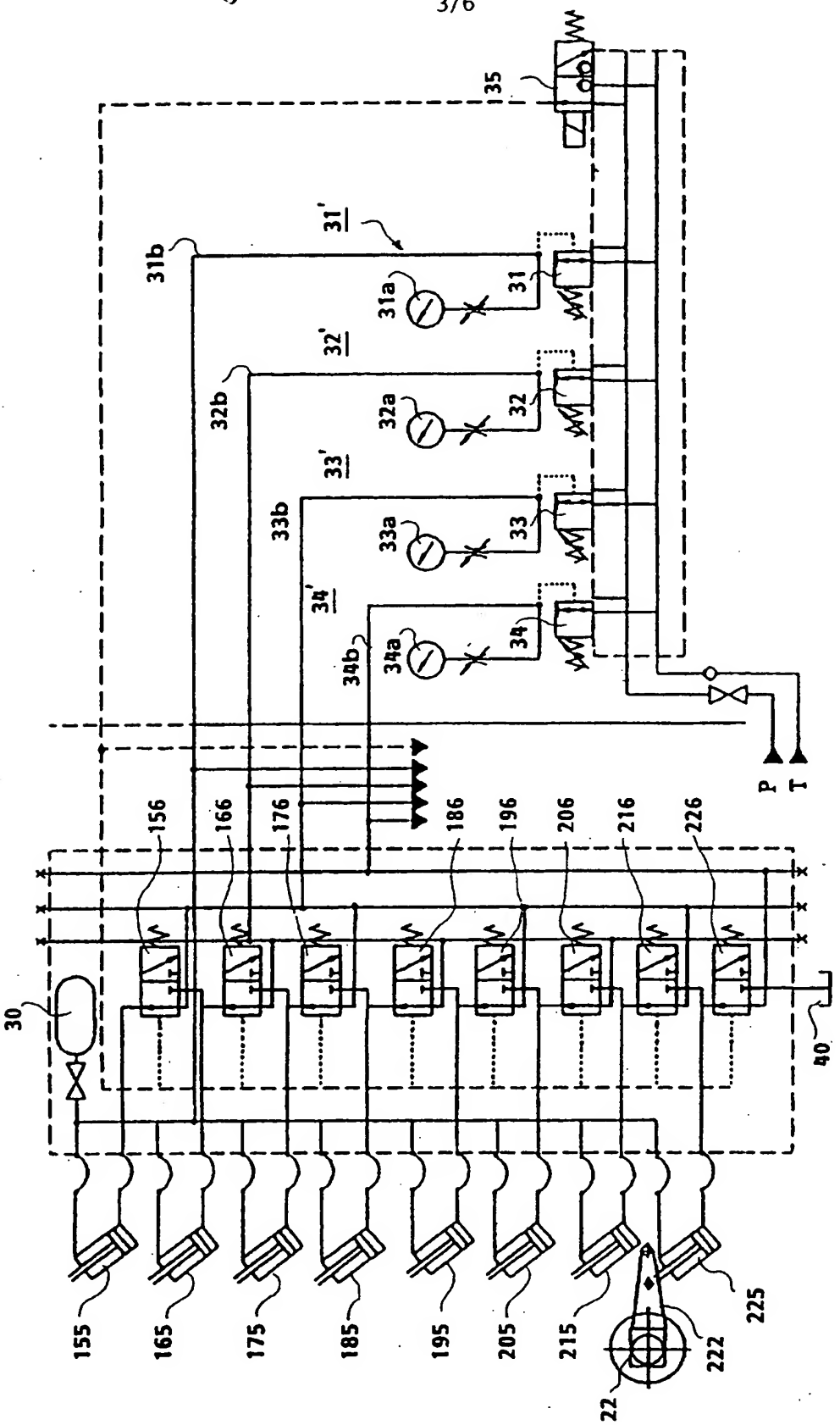
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FIG. 2A

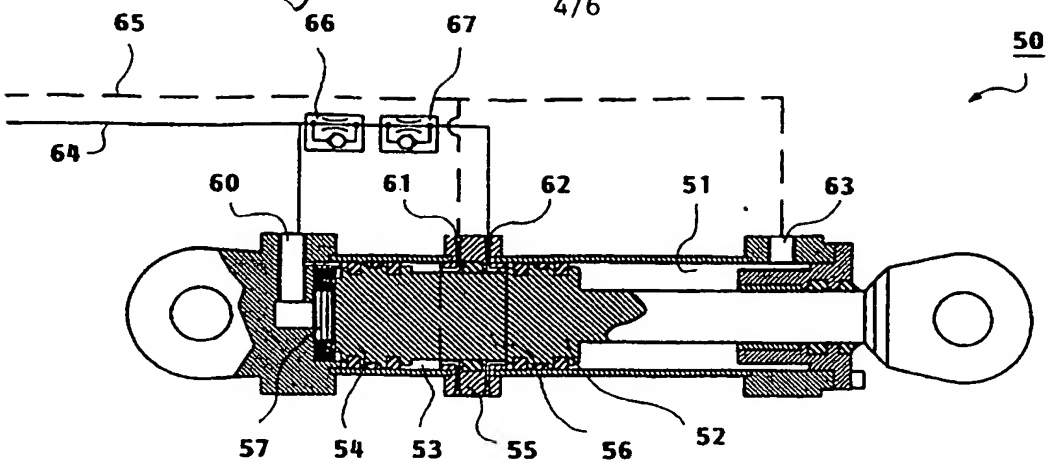

FIG. 3A

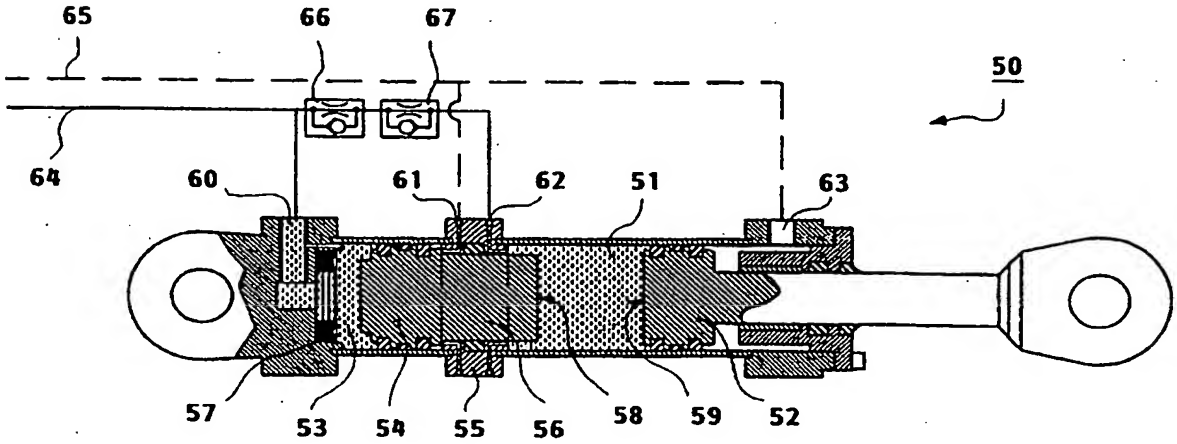

FIG. 3B

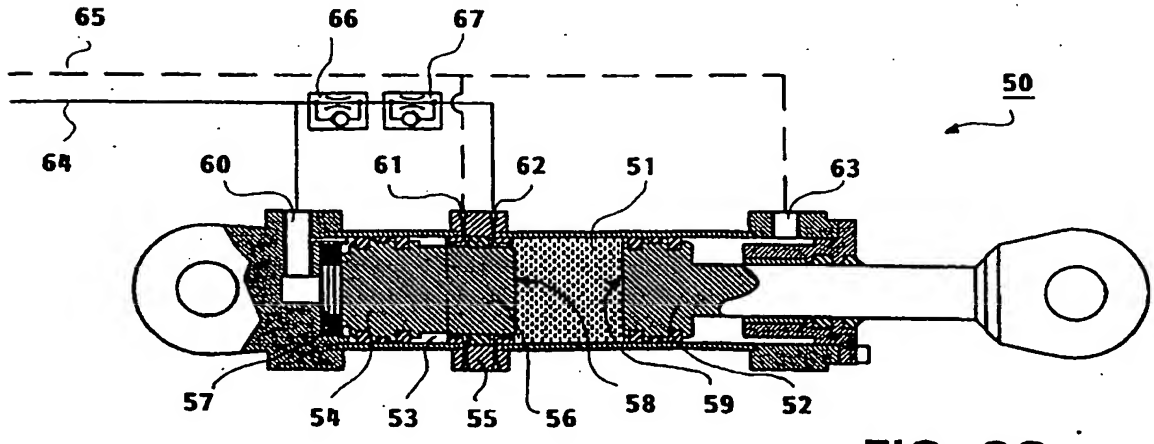

FIG. 3C

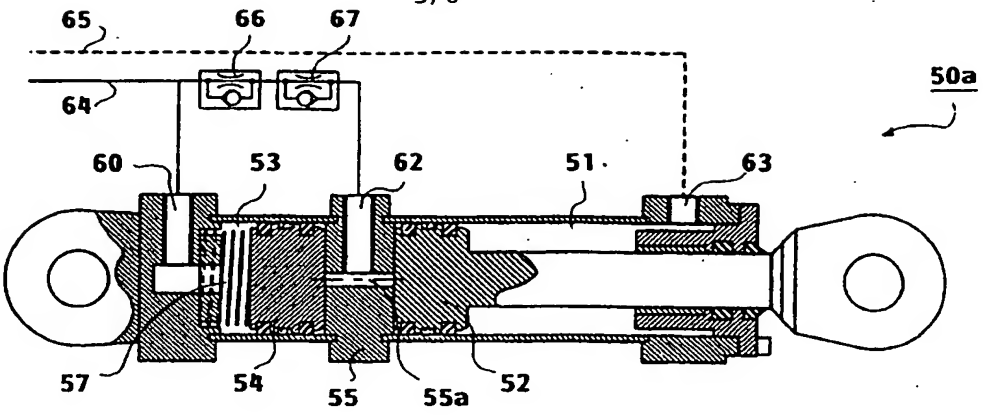

FIG. 4A

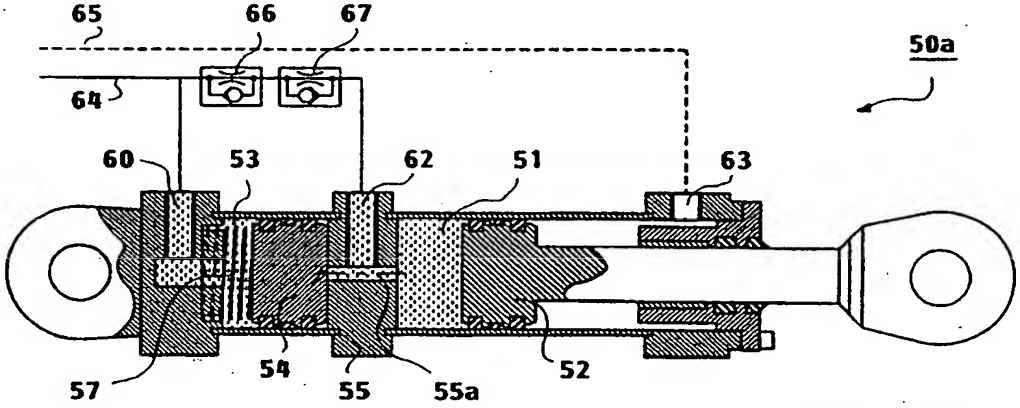

FIG. 4B

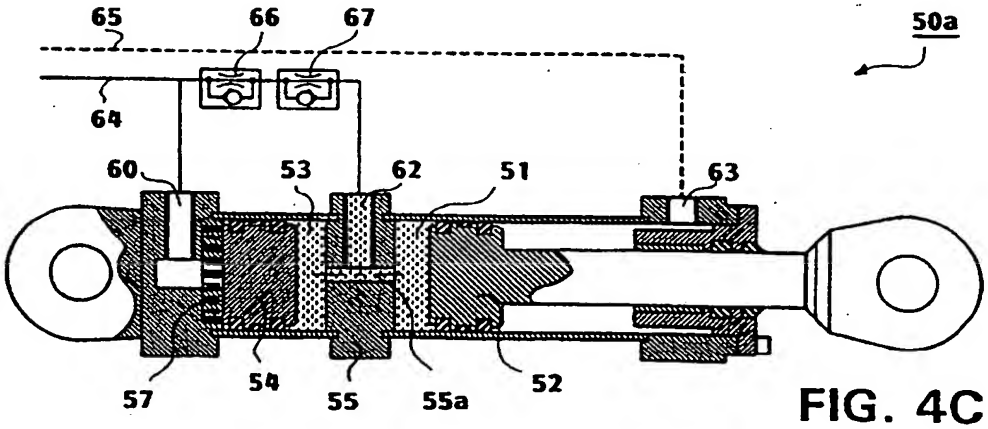

FIG. 4C

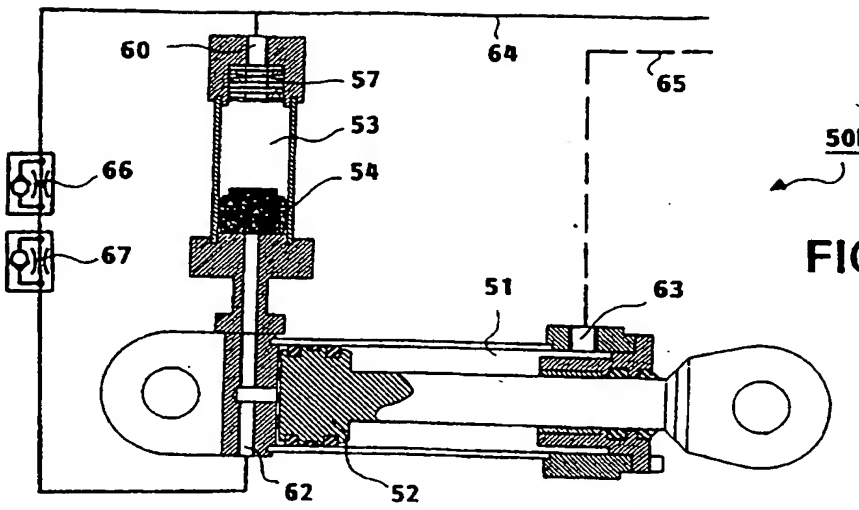

FIG. 5A

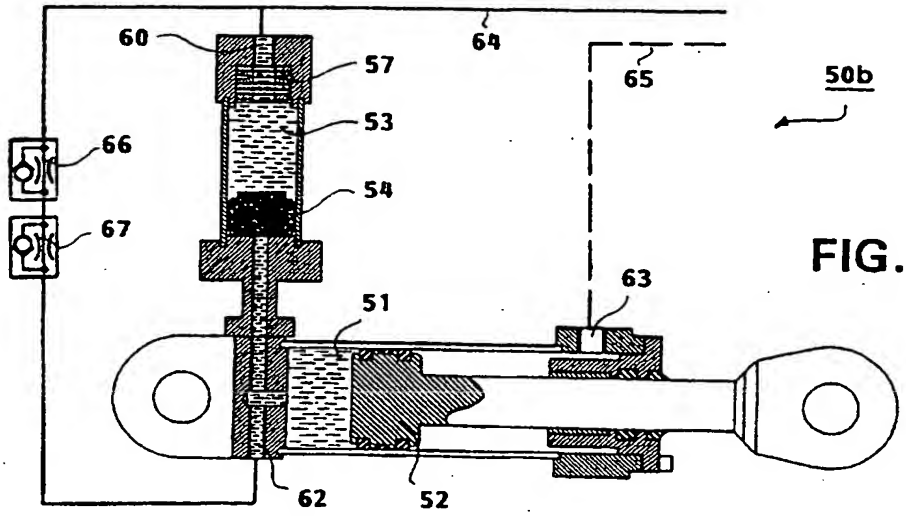

FIG. 5B

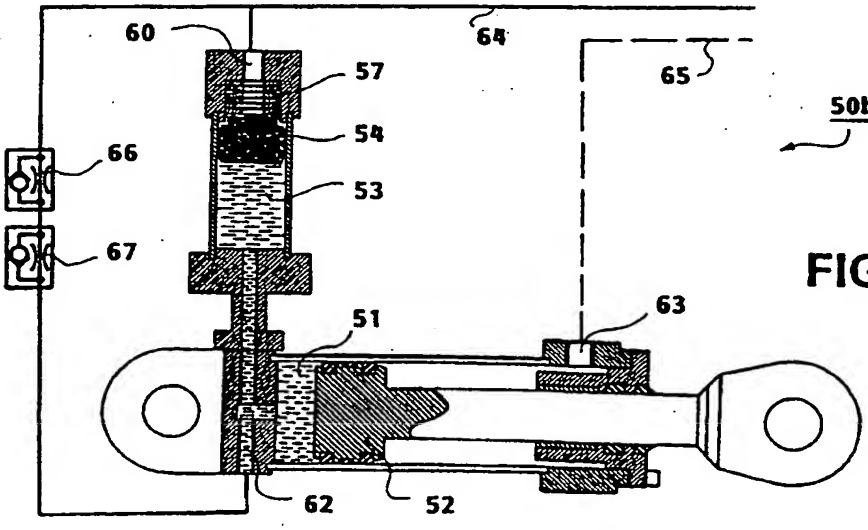

FIG. 5C

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 97/00258

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: D21G 1/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: D21G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

DIALOG: ALLSCIENCE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5438920 A (PEKKA KOIVUKUNNAS ET AL), 8 August 1995 (08.08.95) -- --------	1,8

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
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"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 August 1997	14 -08- 1997
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Olov Jensén Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

06/08/97

International application No.
PCT/FI 97/00258

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5438920 A	08/08/95	CA 2154479 A	01/06/95
		EP 0679204 A	02/11/95
		FI 96334 B,C	29/02/96
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		JP 8506392 T	09/07/96
		WO 9514813 A	01/06/95